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Unusual wave flow over the Midlands

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Summary

Glider pilots have for many years used wave flow in the atmosphere, in the form of mountain waves, to climb to considerable heights and fly long distances. However, although mountain waves are probably the most common form of wave flow, evidence has been accumulating in other countries during the last two decades of wave flow originating in different ways. This article describes what is thought to be the first instance recorded by glider pilots of non-orographic wave flow over England. The meteorological conditions existing at the time were remarkably similar to those described during earlier occasions of non-orographic wave flow over Germany.

Introduction

On 9 May 1979, 29 competitors in the Open Class of the Inter-Services Gliding Championships were tasked with flying a race round a triangular course from Little Rissington, with turning points at Uppingham and Aqualate Mere, near Newport, Shropshire (Figure 1), a distance of approximately 330 kilometres. At the same time a further 17 competitors in the Sports Class were to race around a smaller triangular course with turning points at Ludlow and Bridgnorth.

The forecast promised good gliding conditions with excellent visibility, strong thermals capped by shallow cumulus at 1500–1800 m and a light northerly wind in the convection layer, backing north-westerly at 1500 m. In the event the Sports Class was less fortunate in terms of weather than was the Open Class. Along the first leg thermals were weakened by considerable amounts of 'lenticular' strato-cumulus and, although thermals became much stronger towards Ludlow, an almost complete dis-appearance of cloud made the task of finding them much more difficult. The Open Class, on the other

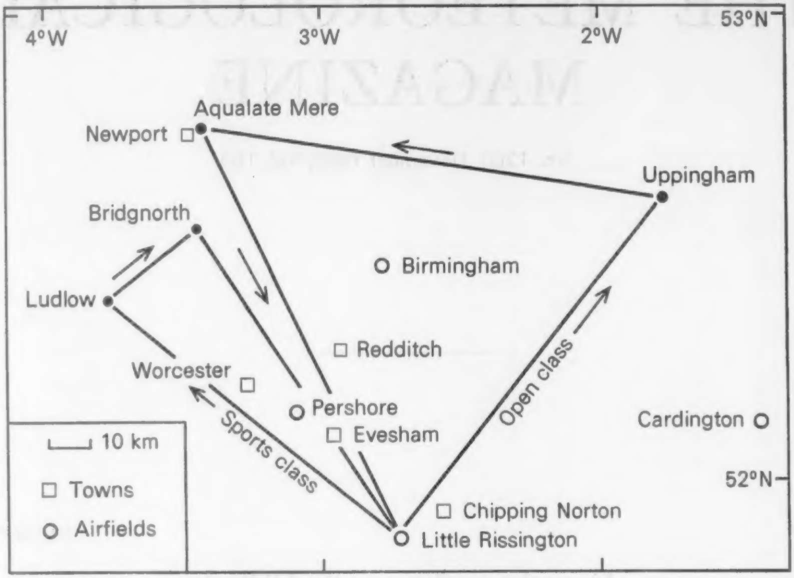

Figure 1. Routes flown by Open and Sports Class competitors on 9 May 1979 between approximately 12 and 18 GMT.

hand, found conditions much as forecast with plenty of thermals beneath cloud streets, although an unexpected reduction in thermal strengths and frequency near Uppingham resulted in a few gliders landing prematurely.

Despite these differences in weather around the two triangles, competitors from both classes were agreed that some form of wave flow was interfering with thermal development during the later stages of the approach to Little Rissington. The Sports Class placed this interference as starting between Worcester and Pershore, while the Open Class placed it as starting between Redditch and Evesham. One Open Class pilot even thought there was wave flow along the second leg, between Uppingham and Aqualate Mere. Clearly, since none of the competitors was able to deviate from the race to explore the conditions, no positive evidence of wave flow could be offered.

However, by fortunate coincidence a non-competitor, Barry Elliot, spent part of the afternoon soaring locally in a K–13, a 2-seat glider, and he confirmed there were indeed waves in the vicinity. Released by a Chipmunk tug at 14 GMT, this pilot climbed in a 2–3 m s^{-1}* thermal from 800 m above sea level to cloud base at 1600 m above sea level. From here he turned west-north-west, into wind, but instead of entering descending air as would normally be expected on leaving a thermal the glider continued to

* Throughout this article no allowance is made for the rate of sink of a glider since this depends on a variety of unrecorded factors. The minimum rate of sink for contemporary gliders is approximately 1 m s^{-1}. Thus the true vertical velocity of the air ascending in thermals is at least 1 m s^{-1} greater than the values given.

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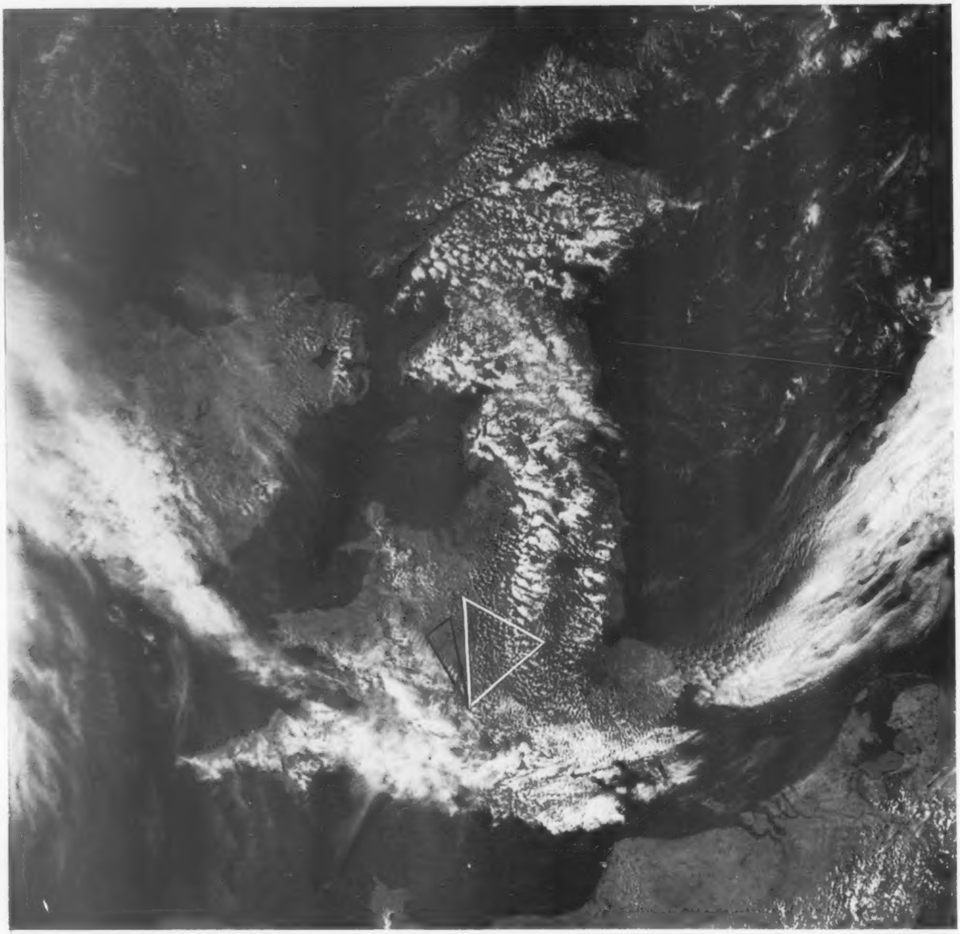

Photograph by courtesy of the University of Dundee

Plate I. TIROS-N satellite picture, 9 May 1979, 1403 GMT. The black triangle indicates the course flown by Sports Class competitors and the white triangle indicates the course flown by Open Class competitors.

rise at 1–2 m s^{-1}. This lift increased to a steady 2 m s^{-1} and persisted above cloud tops (estimated from the tephigram as 1800–1900 m above sea level) up to at least 2300 m above sea level. Regrettably, by this time, 15 GMT, the pilot had used his allotted flying time and had to land, leaving the upper limit of the lift unexplored.

The clouds as seen from the ground were cumuliform, but the pilot observed that the leading edges of all the clouds in the vicinity were lenticular. This effect was subsequently visible from the ground, and by 16 GMT what few clouds remained had become distinctly almond-shaped.

Following this flight there was another report of a glider climbing to about 2000 m above sea level over Chipping Norton, some 12 km to the north-east, but no further details were forthcoming.

Figure 2 is a diagrammatic representation of the chart from the barograph carried by one of the competitors in the Open Class, Air Commodore Cooke, who was flying a Libelle glider. (In competitions all competitors have to carry barographs.) From this it is possible to deduce that even as late as 17 GMT scattered thermals were giving lift of 5 m s^{-1}. Air Commodore Cooke noticed no evidence of wave flow.

Using a TIROS-N picture timed at 1403 GMT, the cloud-street spacing over the Midlands can be measured as 5–6 km. The stratocumulus and subsequent lack of cloud over the Sports Class task area are also clearly shown (Plate I).

A weak, southward moving cold front passed through Little Rissington at about 09 GMT and subsequently became almost stationary as pressure rose to form a shallow low over south-east England (Figure 3). The front is clearly evident on the 1403 GMT TIROS-N picture as a narrow band of stratocumulus over the Bristol Channel and a wider one over the southern North Sea. Convection has caused breaks to develop in the stratocumulus sheet inland but there is a distinct change from the cloudy moist air over southern counties to the relatively dry air over the Midlands. Detail of the low cloud over Somerset, Dorset and Wiltshire is obscured by cirrus, but with no cold advection shown on the 1440 GMT Larkhill pilot-balloon ascent (Table I) the front must still be to the north of Salisbury Plain.

Table I. *Larkhill pilot-balloon ascent,* 9 *May* 1979, 1440 *GMT*

Heights in metres above ground level, speeds in metres per second

Height	Direction	Speed	Height	Direction	Speed
0	275	2·5	1050	300	5·5
150	280	3·0	1200	295	5·5
300	270	2·5	1350	295	6·0
450	285	3·5	1500	295	7·5
600	295	3·5	1650	290	7·5
750	295	4·5	1800	280	7·5
900	295	5·0			

The western extent of the stratocumulus, described by some competitors as 'lenticular', can be placed over Radnor Forest (Figure 4) where the highest ground rises to about 660 m above sea level. This particular area of stratocumulus extends some 85 km to the east-south-east before petering out over the Severn valley, but it should be noted that a similar pattern has developed in the stratocumulus further east where convection has broken up the cloud sheet.

Cloud-free areas near coasts are attributed to the inland penetration of sea air, while just inland of the south coast of Wales a sea-breeze front marks the convergence zone between the onshore south-westerlies and the opposing northerlies (Figure 3(b)).

Upper-air data for 11 GMT indicate winds of 280°–290°, 6–8 m s^{-1} at 1500 m above sea level

Figure 2. Diagrammatic representation of the chart from the barograph carried by Air Commodore Cooke.

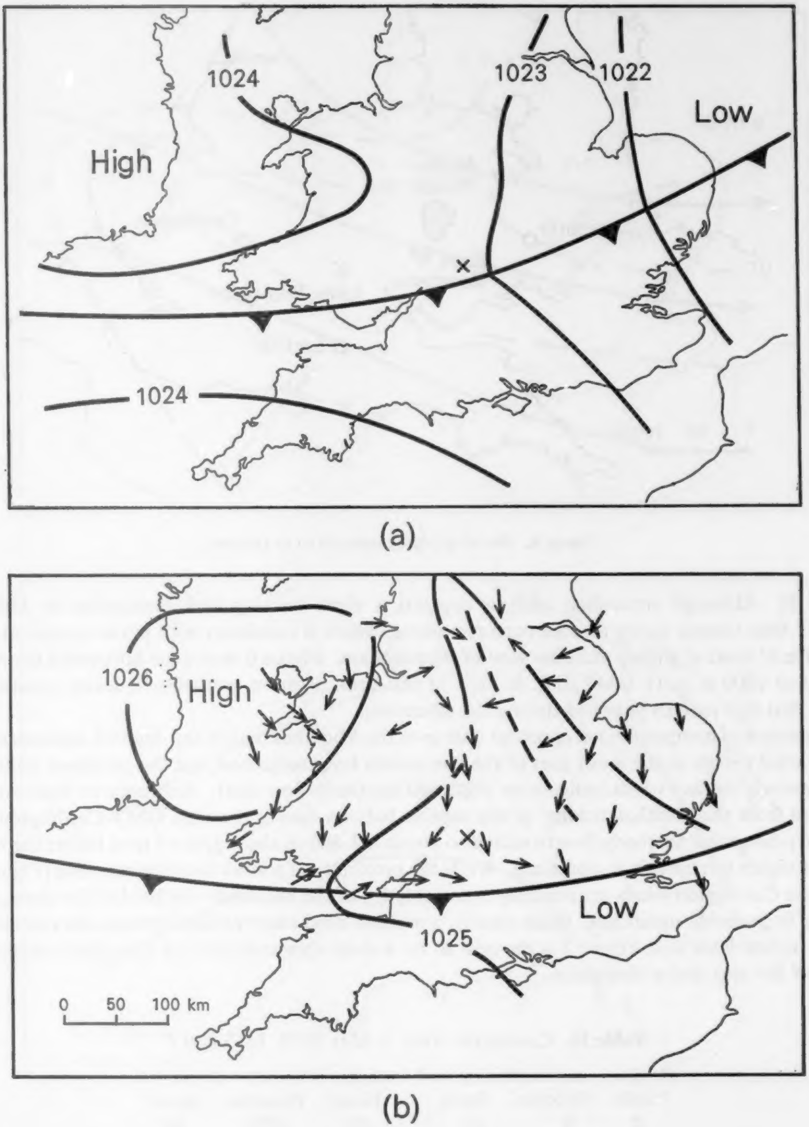

Figure 3. Synoptic situation at (a) 09 GMT and (b) 15 GMT on 9 May 1979. Arrows indicate surface wind directions reported at 15 GMT. Cross indicates Little Rissington.

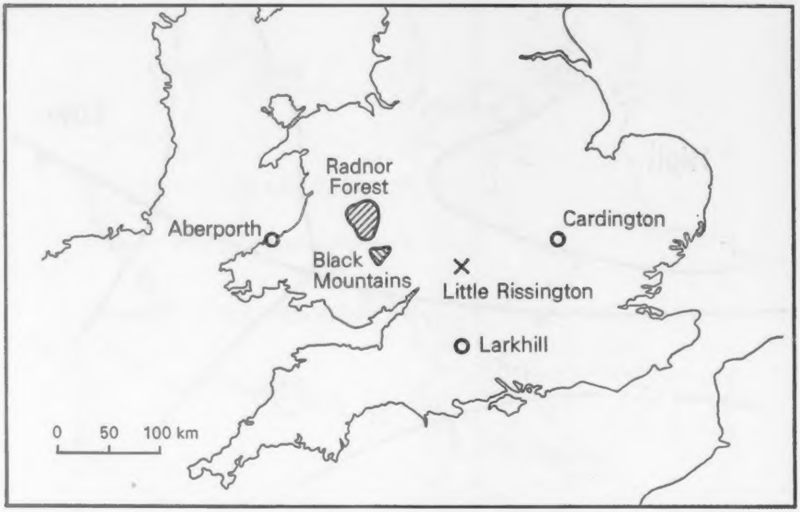

Figure 4. Showing places referred to in the text.

(Figure 5). Although streamline analysis suggests a slight backing and moderation at 1500 m by 17 GMT little change seems to have occurred above, which is consistent with pilots commenting on a 'pretty fresh' wind at gliding altitudes west of Birmingham. Figure 6 shows the horizontal temperature gradient at 1500 m at 11 GMT and, in view of the slack pressure gradients, it seems reasonable to assume that this pattern persisted during the afternoon.

The absence of comprehensive upper-air data over the Midlands makes any detailed assessment of the vertical wind profile in the lower part of the convection layer subjective, but the persistent light north-north-westerly surface winds indicate an organized northerly flow aloft. Reference to wind directions estimated from the 'weathercocking' of the captive balloon during the 1455 GMT Cardington ascent (Table II) shows this northerly flow to extend to about 750–800 m above ground level before the westerly winds at higher levels begin to dominate. While the proximity of a weak convergence zone (Figure 3(b)) means the Cardington winds are not truly representative of the Midlands, the level of the change to the westerly is probably significant. Quite clearly, a marked wind shear existed between the extremities of the convection layer and Figure 7 is thought to be a close approximation to the actual vertical wind profile of the area under discussion.

Table II. *Cardington wind,* 9 *May* 1979, 1455 *GMT*

Heights in metres above ground level, speeds in metres per second

Height	Direction	Speed	Height	Direction	Speed
0	N	2·5	450	NNE	4·0
75	NNE	4·0	600	N	2·5
150	N	3·0	750	N	2·5
225	NE	3·5	900	W	1·0
300	NNE	3·5			

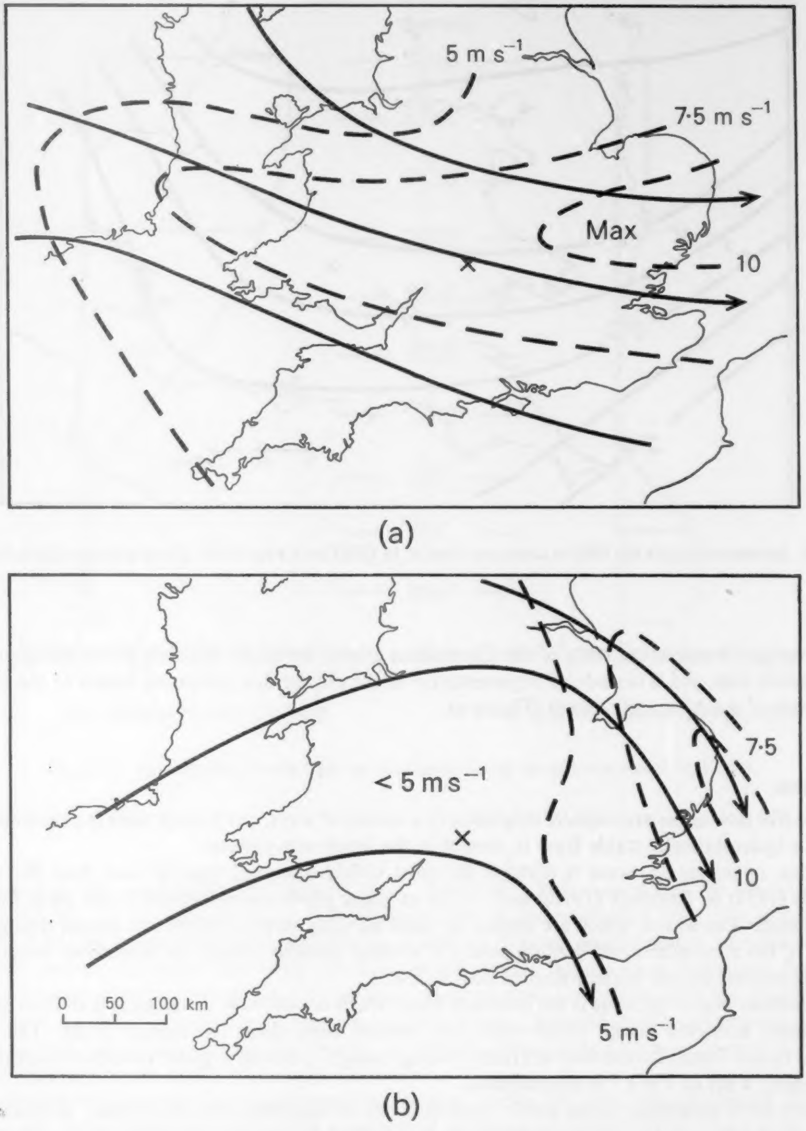

Figure 5. Streamline and isotach analyses for 1500 m above sea level at (a) 11 GMT and (b) 17 GMT on 9 May 1979. Cross indicates Little Rissington.

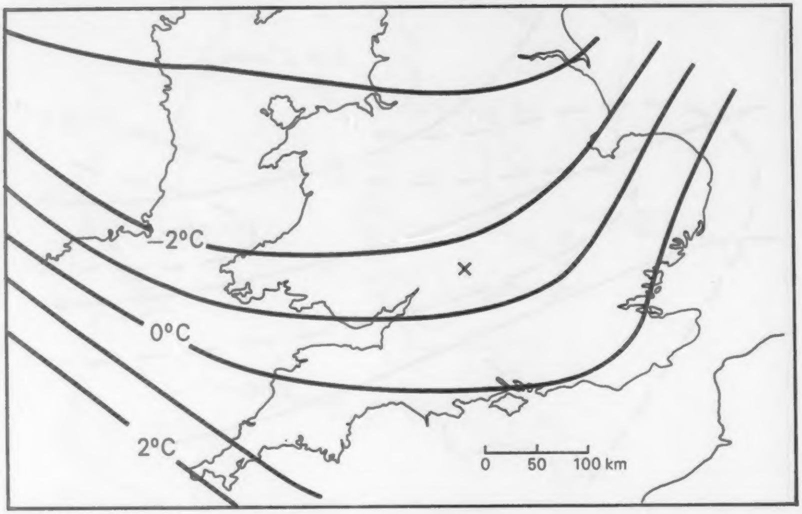

Figure 6. Isotherm analysis for 1500 m above sea level at 11 GMT on 9 May 1979. Cross indicates Little Rissington

The vertical temperature trace of the Cardington ascent shows no evidence of modification by the convergence zone and is considered representative of the change due to heating inland of the air in the lower part of the Aberporth ascent (Figure 8).

Discussion

Wave-like flow in the atmosphere originates in a variety of ways, but in each there is a common factor in that a hydrostatically stable layer is present in the lower atmosphere.

The lee, or mountain, wave is perhaps the most widely discussed type of wave flow (for example Nicholls (1973) or Ruddock (1970)) and, so far as glider pilots are concerned, is the most frequently encountered. Lee waves, which are caused by wind blowing across a ridge, can extend through great depths of the atmosphere and contain powerful vertical currents which are sometimes hazardous to powered aircraft (Royal Meteorological Society 1965).

At the other end of the scale is the inversion wave which occasionally develops in a shallow layer at a temperature inversion across which there is a vertical wind shear (Reichman 1978). The vertical currents in this form of wave flow are rarely strong enough to enable a glider to maintain altitude, but occasionally a lift of 1 m s^{-1} is encountered.

Smooth lift is sometimes found on the windward side of individual cumulus clouds. Kuettner (1972) calls this cumulus wave and notes that the lift does not often extend much above the cloud top.

Finally there is the cloud-street wave, which is similar to the cumulus wave but more powerful and extensive. This form of wave flow is a consequence of wind at and above the inversion level blowing

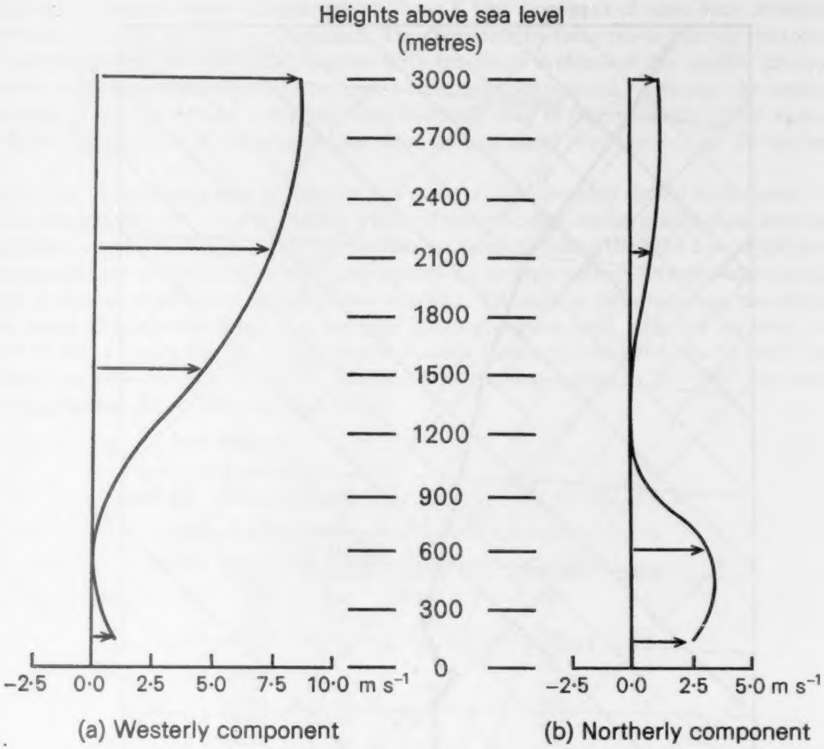

Figure 7. Vertical wind profile over the Midlands during the afternoon of 9 May 1979.

across cloud streets—and hence the low-level wind. Jaeckisch (1972) summarizes the synoptic conditions favourable for cloud-street wave flow as weak flow in the convective layer and a horizontal upper-air (850 mb) temperature gradient with the isotherms directed approximately at right angles to the surface isobars, the upper flow being across the cloud streets. Besides these conditions, Reichman (1978) noted that a further contributive factor in cloud-street wave formation is for the wavelength of the air above the cloud to be similar to the cloud-street spacing. (It could possibly be argued, however, that the latter is partly dependent on the former, since the downdraught of a wave system would inhibit cloud formation and the updraught would assist it.)

Cloud-street wave flow was first experienced in Germany during the early 1960s (Jaeckisch 1970) and, although the phenomenon has since been experienced elsewhere (Kuettner 1972), there is no known record of it in the British Isles. (Bradbury (1973) discusses a possible occurrence but this was associated with a line of vigorous cumulonimbus, not an organized system of cloud streets in which the clouds

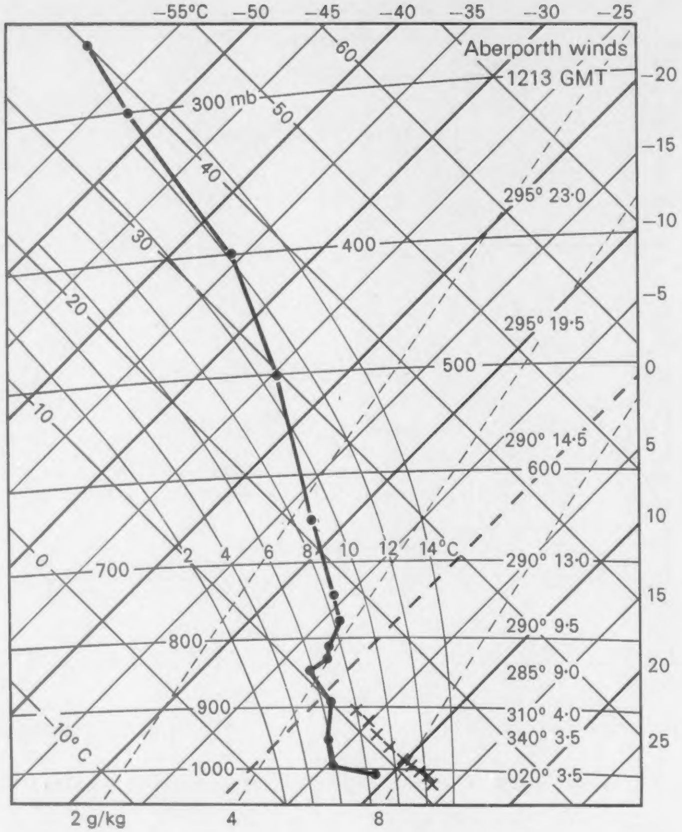

Figure 8. Aberporth and Cardington ascents during the afternoon of 9 May 1979.
●——● Aberporth 1213 GMT (winds in m s⁻¹).
×——× Cardington 1455 GMT.

were of limited vertical development.) Compared with lift in inversion and cumulus wave flows, lift in cloud-street wave flow can extend to considerable heights above cloud tops (some 1800 m in one early report (Jaeckisch 1970)) and the rate of lift normally seems to be about 2 m s^{-1}.

Following Scorer (1953) and using a scale devised by Wallington (1953) it can be shown that on this occasion the wavelength between 1800 m and 2300 m was probably very close to the cloud-street spacing of 5–6 km as measured from the satellite photograph. Between 2300 m and 2700 m the wavelength increases to 9–10 km, so it is unlikely that the lift encountered by the K–13 glider would have extended much higher.

Because of the vertical extent and strength of lift on 9 May two types of wave flow, inversion and cumulus wave flow, can quickly be eliminated. The comments by some pilots that the stratocumulus west of Little Rissington was lenticular, together with the visual evidence of the satellite photograph, do, however, support the idea that the waves were orographically induced. Although the easternmost cloud element of the 'wave train' extending from Radnor Forest is approximately 20 km west-north-west of Little Rissington it is conceivable that wave motion could continue in clear air beyond this point.

However, for orographic waves to develop it is essential that the wind should blow across a ridge, in this case from about 290°. Unfortunately, a lack of synoptic data makes it difficult to ascertain the true wind flow over central Wales on 9 May. On the one hand, assuming the wind flow at 400 m (taken as the average altitude of Radnor Forest) closely follows the isobaric pattern, then the flow was between north and north-east from about 06 GMT that morning. Supporting this argument, the observer at Trecastle, some 50 km to the south-west but only 312 m above sea level, recorded the wind at 050°, 1 m s^{-1} at 15 GMT, while 100 km to the west of Radnor Forest at Aberporth the 12 GMT wind at 600 m above sea level was 340°, 3·5 m s^{-1}. Above 600 m the wind backed to 280°–290° then remained constant in direction above 1200 m (Table III).

Table III. *Aberporth radar winds,* 9 *May* 1979, 06 *and* 12 *GMT*

Heights in metres above sea level, speeds in metres per second

	Height	06 GMT Direction	06 GMT Speed	12 GMT Direction	12 GMT Speed
Surface	132	360	3·0	020	3·5
	500	005	5·0	—	—
	600	—	—	340	3·5
	900	360	5·0	310	4·0
	1200	—	—	295	5·5
	1500	295	8·0	285	9·0
	1800	—	—	285	7·0
	2000	280	10·0	—	—
	2100	—	—	290	9·5

On the other hand, as much of central Wales lies above 400 m above sea level it could be argued that the surface wind can be estimated from the 1300 m wind in much the same way that Findlater *et al.* (1966) relate the surface wind near sea level to that at 900 m. If this is a valid argument then the wind over Radnor Forest could well have been 280°–290°, 4 m s^{-1}. Therefore, with a slightly stronger wind at ridge levels (maximum elevation 660 m above sea level), it is possible that lee waves could have developed. Even so the theoretical maximum vertical velocity would have been only 1 m s^{-1} at 1500 m (after Casswell 1966), half the observed rate of lift, and this would have occurred close to the source of the wave.

Nicholls (1973), for example, describes a well-defined mountain wave system originating over the Black Mountains in a south-westerly airstream. Even though the wind at 600 m above sea level was 10 m s^{-1} and the maximum vertical velocity measured as 2·5 m s^{-1} the wave motion was quickly damped down some 50 km from the point of origin, although minor waves persisted beyond this point. Therefore, even if a west-north-westerly wind had existed across Radnor Forest on 9 May, it is unlikely that the wind would have been strong enough to maintain a wave train, in which the observed vertical velocity was greater than the theoretical maximum vertical velocity, some 85 km or so from its source.

Thus, although there must be considerable doubt whether mountain waves could have existed, all the conditions required for cloud-street wave flow were present—the weak surface flow, upper winds blowing across the cloud streets and a cloud-street spacing similar to the wavelength of the air above the inversion.

Conclusion

Undoubtedly wave flow which was not of the usual type was present on 9 May 1979. Although mountain waves can exist above a cumulus field (Bradbury 1963) the wind regime on this occasion was not really suitable for the development of marked mountain waves and, on balance, the evidence points to another sort of wave flow—cloud-street wave flow.

Since a powered glider would have been available to make a comprehensive survey of the area, it must remain a matter of regret that, as forecaster on the day in question, I did not immediately recognize the significance of the competitors' comments about wave flow. Like most forecasters and glider pilots I was conditioned to think of only one form of wave flow—mountain wave flow—which is not really surprising considering the lack of comments on any other form of wave flow in British publications.

The conditions under which this particular event occurred are not very unusual and it may well be that cloud-street wave flow is a more frequent phenomenon than its absence from the literature would suggest.

Acknowledgements

I should like to thank all those competitors at the 1979 Inter-Services Gliding Championships who were good enough to describe their experiences (to an initially disbelieving forecaster) and especially Barry Elliot, Air Commodore Cooke and Sergeant Hancock. I am also grateful to the University of Dundee for permission to publish their satellite photograph.

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World surface climatological data—methods of quality control and archiving

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Summary

A detailed description is given of a quality control scheme developed for use with world CLIMAT data. Manual and computer-based methods are used, in each case where they can be applied most effectively. There is also a considerable degree of checking between the various methods.

The general quality of transmitted CLIMAT data is found to be not good and it is hoped that, as the World Climate Programme gathers momentum, there may be a definite improvement.

Introduction

The study of climate and climatic change has its basis largely in instrumental records, particularly of pressure, temperature and rainfall. The averages or totals of the numerical values of these variables over a calendar month have been standard climatological parameters for almost as long as the instrumental records themselves. It is on the evidence of such data that hypotheses on climatic change will be tested.

Over the years, as nearly every country has come to realize the importance of climatic data, a global network of climatological stations has been developed. There are now about 1500 stations in the world which are scheduled to report each month. A considerable amount of work has been and is being done to extend regional data series back in time. Much of this work involves searching through old diaries, parish registers and the like. Less effort seems to have been put into the problems of maintenance and quality control of data series in real time; this has been the task of a small team in the Synoptic Climatology Branch of the Meteorological Office for a number of years, although the detailed checking procedures have been developed only recently.

Bryant (1979) has already given a detailed description of the method used in the examination and storage of climatological data from stations in the United Kingdom (plus a few overseas). There are some similarities in the methods described here, mainly in the manner of transferring data from written records to magnetic storage.

Collection of data

Surface and upper-air climatological data are received at Bracknell by the Global Telecommunication System (GTS) and may arrive either as teleprinter hard copy or as output retrieved from a data set which is continuously updated. The messages are not decoded before they are entered into the data set and the only automatic sorting is on output when surface, upper-air and the other types of climatological message are printed separately.

Most of the data arrive within a fortnight or so after the end of each month. Extraction is normally from teleprinter copy and the data are entered into 5-year data books under the appropriate headings—pressure, temperature, vapour pressure and rainfall (including number of rain days and the appropriate 'quintile'* for the month). Hours of sunshine and percentage of normal sunshine are currently entered

* The use by meteorologists of the word 'quintile' to denote ranges of a variable such that each range contains one fifth of the total number of observations is anomalous and not acceptable to statisticians. The quintiles are normally defined to be the four boundaries between such ranges.

in a separate book, but will be included in the same book as the other parameters from 1981. Whenever possible, departures from normal are calculated at the time of entry and are later entered on northern hemisphere charts.

A few countries send confirmation copies which start arriving about mid-month. These are particularly useful since they are free from transmission errors and may have been compiled with more care than the teleprinter messages.

Initial quality control

Entry into books provides immediate comparison with previous data (up to four years) which is a useful first step in the quality control procedure. Plotted charts of monthly mean sea-level pressure, temperature, total rainfall and sunshine provide spatial quality control. The surface-pressure chart is analysed in the normal way using actual values but the others are analysed on the basis of departures from normal, providing a much more coherent field than the actual values. Inevitably, in many areas the average distance between stations is too great for anything but very rough intercomparisons of means and anomalies to be made. However, large apparent inconsistencies are easily recognizable and can be checked without much difficulty. Where there is a good density of stations doubtful values stand out clearly.

Keying to magnetic tape

About three weeks from the beginning of each month, when most of the data have been logged and checked, keying forms are completed and sent to the Processor-controlled Keying (PCK) section (Figure 1).

Each form is headed with a 5-figure month/year group which is automatically added to the start of each record as it is keyed. The rest of the record is very similar to the original CLIMAT message but with two differences: there is only one field for pressure data, normally occupied by sea-level values, but by station pressure for high-altitude stations; and at the end of each record a single number is allocated to a flag value which indicates the relative position of any doubtful element. If two or more elements are doubtful a flag value of zero (0) is used.

The keying process involves each element being assigned a field. If it has not been reported, it is skipped and a 'missing' value of − 32768 is automatically entered. Simple checks are also included: for instance the maximum allowable number of rain days is 31 and the quintile value cannot exceed 6. These checks both detect incorrect fields caused by errors in field-skipping and provide a further test on the entered values. The most effective keying check, however, is provided by the verification process described by Bryant (1979) in which all the data are keyed a second time and automatically checked against the values originally entered.

Further quality control (automatic)

Once the keying process has been completed and the data are on magnetic tape, a working copy is made. The PCK tape is retained as a back-up until the processed data have been written to the final archive tape. A series of programs is run which check, correct and sort the data. The first program does the checking and provides an output of exactly what has been entered. The tests in detail are as follows:

Pressure. The abbreviation of sea-level pressure values (reported in tenths of a millibar) precludes any numerical value greater than 0999. The minimum station-level pressure so far encountered is greater than 600 mb, so any value between 1000 and 5999 is assumed to be erroneous. Such errors are normally the result of incorrect field-skipping.

CLIMAT SURFACE DATA

MONTH	YEAR
12	979

Sheet No. 14

NUMBER		PRESSURE (mb) M.S.L. (but S/F for high-level stations)	TEMPERATURE (°C)		VAPOUR PRESSURE (mb)	RAINFALL (trace=9999)			SUNSHINE		FLAG
Block	Station		Minus = 1			Rain days ≥1 mm.	Amount (mm.)	Quintile	Amount (hrs)	% ÷ 5 of normal	
41	715	180		172	114		7	5			
	739			127	77	2	15	4			
	756	170		205	170	13	39				0
	765	180		200	113	3	3	4			5
	768	170		181	117	0	0				
	780	170		197	115						
42	027	846									
										14	
						3	17	5	287	19	
				242	183	0	0	4			
	133	149		223	141	0	0	4			
43	041	158		192	152	2	11	5			
	057	135		267	241	0	0	4	289	20	
	063	143		212	157	0	0	4	300	21	
DO NOT PUNCH THIS SECTION →		1	2		3	4	5	6	7	8	

One of these numbers included in 'FLAG' column indicates that the element to which it refers has been altered, or is suspect. Value 0 (zero) indicates that two or more elements are suspect or have been altered.

Figure 1. Example of keying form from which CLIMAT data are keyed to tape.

Notes:
Block numbers are repeated on the tape until a new block number is encountered.
41756 vapour pressure and rain days were considered doubtful—suspect transmitting error in this case.
41765 rainfall doubtful.
Sunshine percentages of normal as coded—multiply by 5 to obtain value.

Temperature is effectively tested twice. First, values outside the range − 65 °C to + 40 °C are excluded. (Vostok base in Antarctica frequently reports monthly means below − 65 °C, but for any other stations such values would almost certainly be erroneous.) The second test uses the relationship between saturation vapour pressure e_s and temperature T. The relationship used here has been derived from observation and provides a more rigorous check than simply using the empirical e_s/T equation.

$$\ln e < 0{\cdot}006 \times T + 4{\cdot}23,$$

where e is vapour pressure (mb × 10) and T is temperature (°C × 10). Queries raised by this test are normally the result of doubtful vapour pressure values (except when temperature has already been flagged), since no other check is applied to this element.

Rainfall and *rain days* are tested for consistency. A rain day is defined as one in which 1 mm or more of rain has fallen; thus the number of rain days cannot numerically exceed the rainfall. Both rain days and quintile have already been checked during the keying process and an upper limit cannot be specified for rainfall.

Finally, values of *sunshine duration* in absolute terms and as a percentage of normal are tested individually and together. The theoretical maximum amount of sunshine in a 30-day month is 720 hours in high latitudes in summer and this value cannot be exceeded. It is rare for sunshine to exceed 250 per cent of normal, so an upper limit of 300 per cent is specified.

Only very recently a comprehensive set of confidence limits has been developed. They were calculated using the World Historical station data sets, which are largely based on World Weather Records and were created within the Synoptic Climatology Branch from tapes supplied by the National Center for Atmospheric Research, Asheville, North Carolina. For temperature and pressure data the confidence limits are defined as:

$$\bar{x} \pm 3\sigma_{n-1},$$

where $\bar{x}$ is the mean and σ_{n-1} is the standard deviation of values in the normal period. For rainfall data they are:

$$\bar{x} + 1{\cdot}5(x_{\ -1} - \bar{x})$$
$$\text{and} \quad \bar{x} - 1{\cdot}5(\bar{x} - x_{\mathrm{L}+1}),$$

where $x_{\mathrm{G}-1}$ and $x_{\mathrm{L}+1}$ are respectively the next highest and next lowest rainfall totals during the normal period. Should the expression give a negative lower confidence limit, it is set to zero.

Not all keying errors or omissions in the manual quality control procedures can be detected by the above checks. Scrutiny of the keyed data is also necessary, with reference to data books and plotted charts for chronological and spatial comparisons. None the less, automated checking is a useful component of the quality control system.

Corrections and final checks

Corrections and additional flags shown to be necessary by the above checks are incorporated before ordering the data according to World Meteorological Organization (WMO) block/station number. These numbers are themselves checked by reference to a list of stations from which records have been received during the previous three years. Any reported station numbers not on the standard list are printed out, as are the numbers of stations from which data have not been received. The former list is more important since it represents either a keying error or occasionally a new station, which would be added to the standard station list after reports for three consecutive months have been received. There is also a test for duplicate station numbers, which normally result from a report being entered twice.

Additional corrections shown to be necessary at this stage necessitate repeating the procedures described in this paragraph.

Late data and further checking of flagged records

Occasionally, late reports arrive by teleprinter in the form of 'retard' messages, but it is necessary to wait for the relevant issue of *Monthly climatic data for the world** (MCDW) for most missing data. This

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* MCDW is produced by the US Department of Commerce and is published by the National Oceanic and Atmospheric Administration (NOAA) with sponsorship from WMO.

also provides a useful opportunity for checking those values which have been flagged. These late data and corrections are entered on punching forms in the same way as are the 'real-time' data, even when a record is being corrected. The subsequent routine of quality control, keying and checking is as already described and the data are finally written to a 'late data' tape.

Once all available data for a year have been written to tape, they are added to the World Historical data sets of pressure, temperature and rainfall. (This is some months after the end of the year in question since the aim is to include as many data as possible.) Flagged elements are assumed to be missing for the purposes of archiving, but a list is kept so that they may eventually be obtained from other sources, such as national meteorological yearbooks.

Problems and comments

The most obvious and numerous problems are a result of coding and transmission errors. Whereas SYNOP and other frequently used codes are well understood by users, there is considerably less familiarity with the CLIMAT code and, despite clearly defined rules, a wide variety of non-standard headings and message formats are received. These normally present no problem to the human eye but there are considerable complications in designing a system of message handling by computer. Furthermore, savings in staff time are unlikely to be significant. The only automatic sorting attempted is between surface, upper-air and other types of message. Even then, the basic indicator (CS, CU, CE, etc.) is sometimes omitted, causing the subsequent message to be output in the same stream as the previous message. For these reasons, it has been decided not to automate message handling any further.

The time of receipt of climatological messages, as opposed to synoptic data, is relatively unimportant. Quality is of far greater concern and unfortunately the general quality of the message contents is not good. For instance, there is a WMO requirement for sunshine data to be added to CLIMAT reports (World Meteorological Organization 1972), yet some countries never include it. Rainfall is occasionally reported in millimetres and tenths rather than whole millimetres and there appears to be confusion over the definitions of rain days and quintiles. A day of rain, as defined for the CLIMAT report, is one in which 1 mm or more of rain has fallen (World Meteorological Organization 1972). However, regional practices are such that more than one definition may exist. In the Meteorological Office, for example, a 'rain day' is defined as having 0·2 mm or more of rainfall, whereas a 'wet day' has 1 mm or more. It is probable that some countries use the former definition, or a local equivalent, in their CLIMAT reports.

In regions or seasons of plentiful rainfall, quintile boundaries are based on equal divisions of the frequency distribution during the normal period. Quintile values 0 and 6 denote rainfall totals respectively less than and exceeding any value in the normal period. Where rainfall is sparse, the quintile is a description of the frequency of months without rain; the more dry months there are, the higher is the quintile. In such cases the quintile is of little value, but even when the quintile and rainfall may be expected to have some relationship it is frequently not evident.

There are times when CLIMAT messages appear to have been hastily compiled and transmitted, perhaps because they are an extra component in an already tight work or transmission schedule. Confirmation copies sent by post are of considerable assistance and it would be helpful if they were made the rule rather than the exception. Much of the data published in *Monthly climatic data for the world* is based on telecommunication reports. Unfortunately, there has been little quality control and it is frequently not possible to correct doubtful values from this source.

Changes of site and instrumentation

The effects of site and instrument changes are potentially the most serious from the climatological viewpoint. If the stations are closed, resited or re-equipped, the effect on the climate record may easily be mistaken for a true variation in climate. Past data are full of 'pseudo-variations' of this sort which require detailed station histories to resolve them. This would often involve reference to the country of origin for the necessary information.

Acknowledgements

The undoubted value of the climatological archive owes much to the dedication and consistent work of the 'CLIMAT Lab' staff in the Synoptic Climatology Branch of the Meteorological Office. To them, both past and present, I can only offer my thanks.

References

Bryant, G. W. 1979 Archiving and quality control of climatological data. *Meteorol Mag*, **108**, 309–315.

World Meteorological Organization 1972 Manual on Codes, Vol. 1 International Codes. Geneva, Secretariat of the WMO.

Mrs Dorothy Groves

We record with great regret the death on 30 June 1980 of Mrs Dorothy Groves, widow of the late Major K. G. Groves, O.B.E., J.P., M.A., LL.M.* Mrs Groves, daughter of the American foreign editor of the *Daily Express*, was co-founder with her husband of the L. G. Groves Memorial Prizes and Awards† and attended every presentation ceremony with him from 1946 to 1977. Quieter and more retiring than Major Groves though she was, her charm and grace of manner added much to the atmosphere of a unique ceremony, and in 1976 she herself presented the Meteorological Observer's Award.

Notes and news

Retirement of Mr D. McNaughton

Mr D. McNaughton, Assistant Director (Telecommunications), retired from the Meteorological Office on 9 October 1980 after a career of 42 years.

Don McNaughton was educated in Coatbridge, Lanarkshire and joined the Office in 1938 as an Assistant III. In 1941 he went to Canada where he became involved in the meteorological aspects of the Air Training scheme and later underwent forecaster training at Toronto University. He was promoted to Assistant II in 1943 and became a Flying Officer in the RAFVR the following year when he returned to the United Kingdom. In 1945, after retraining for radiosonde work at Downham Market, he went first to Lerwick (where he was demobilized in 1946) and then to the Falkland Islands as the Experimental Officer in charge of the Radiosonde Unit. He was subsequently seconded to the newly created meteorological service of the Falkland Islands Dependencies Survey in 1951 and remained there for a further four years, during which time he made his début into the communications field as Director of the local broadcasting service.

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* *Meteorol Mag*, 1979, **108**, 316.
† *Meteorol Mag*, 1975, **104**, 57.

After his return to the United Kingdom in 1955 he received further training in forecasting duties and went to London/Heathrow Airport where he was promoted to Senior Experimental Officer in 1957. Two years later he took charge of the newly opened Glasgow Weather Centre and remained there for the next seven years, showing great enthusiasm for pioneering new areas of public service work, giving numerous talks and presentations on radio and television and clearly enjoying the wider outlets for his organizational flair. On promotion to Chief Experimental Officer in 1967 he returned to the civil aviation field and subsequently 'shuttled' between London Airport and the parent Headquarters Branch at Bracknell for the following five years.

He finally transferred to the Telecommunications Branch in 1972, at a time when the Office's first message-switching computer system was entering service, and took charge of the Meteorological Telecommunication Centre two years later when the main functions of the Centre became computerized. Mr McNaughton was appointed Head of Branch in 1976 and has spent the past four hectic years devising means of coping with the ever-increasing volume of data passing through the Centre, and with the constant demands of users throughout the Office for more and more telecommunication facilities. He has met these relentless pressures with good humour and steady application, inundating his colleagues with an eloquent outpouring of prose on every topic within his purview. He is widely known and respected for his contributions to international planning and collaboration in the telecommunication field.

Don McNaughton does not have any immediate plans to move house, or to substitute any one pre-predominant activity for that which he leaves behind with some regret, but we wish him and Mrs McNaughton a long and happy retirement and a personal microclimate providing anomalously low pollen counts.

M. J. Blackwell

Investigations of dust cloud from Mount St Helens volcano

Following the eruption of the Mount St Helens volcano on 18 May, which created great public interest, forecast trajectories were calculated on 21 May and the following two days for two levels in the upper troposphere; they indicated that the main dust cloud in the troposphere would reach North Africa on 23 or 24 May. At short notice, the Hercules aircraft of the Meteorological Research Flight was detached to Gibraltar on 23 May to study the passage of the plume. A dust cloud was successfully sampled on 24, 25 and 26 May off the north-west coast of Africa between 26 000 and 31 000 feet. In addition, the Canberra aircraft was used to take samples of dust in the stratosphere over and near the United Kingdom. At the time of writing (August) the analysis of the samples is not complete.

100 years ago

The following extract is taken from *Symons's Monthly Meteorological Magazine*, November 1880, **15**, 156–157:

WILL-WI'-THE-WISP.

To the Editor of the Meteorological Magazine.

SIR,—I think you said in the Magazine some time ago that you had never met with, in the flesh, the man who had seen the *ignis fatuus*, or Will-wi'-the-Wisp. I beg to enclose a paragraph which I cut out of the *Fife News* newspaper some weeks since, and you will see from it that it has been seen there. I can also tell you that in 1832, when a boy herding cows on the farm of Crosshouses, near Kingskettle.

Fifeshire, that I had frequent opportunities of seeing Will-wi'-the-Wisp, or "Spunkie," as it is called in the old Doric.

On the farm of Crosshouses was a bog, about 300 yards from the door of the dwelling-house, and it was in the bog—or rather over the bog—that I saw the light moving about. The best description I can give of it is that it resembled that of a lantern being carried about by a person for some twenty or thirty yards. Sometimes I had seen it move zig-zagly about these distances, and sometimes in a straight line, and always at the same rate of speed—that of a person's usual speed when walking.

My grandfather frequently saw it. Sometimes, when coming in from suppering the horses, he would cry in haste to come out and see "Spunkie" in Pilkim Moss, when I, and the others at the fireside sitting, would run to the door to see it. When all of us were either less or more afraid of the wandering light, many times I have gone to bed at once—*after prayers though*—and buried my head among the bed-clothes that "Spunkie" might not get hold of me; for every person regarded the phenomenon with dread.

I also saw it in a bog called Powglass, on the farm of Dawnfield, close by Crosshouses, several times in the same year, 1832. I have lived since, as a gardener, in four counties in England, and four in Scotland, but never saw "Spunkie" in either of them. I must say, however, that no bogs—or rather quagmires, for Powglass bog partook more of the quagmire—were in close enough proximity to where I lived, in those eight counties, to give me a chance of seeing Will-wi'-the-Wisp again.

Powglass bog and Pilkim bog have both been drained, and "Spunkie" is no longer seen there.

I have one or two cousins still living in the parish of Kettle, who, I am certain, will vouch for the truth of what I have stated to you.

Regarding the paragraph enclosed, I think I can procure the address of the writer of it, on application to the office of the *Fife News*, Cupar, Fife. DAVID ELDER, Gardener.

Silverbut Hall, Hawick, June 21st, 1880.

"STAR.

"WILL-WI'-THE-WISP.—Under the rapid march of improvements in draining, Jack-wi'-the Lantern, or Will-wi'-the-Wisp, has of late years been rarely seen in this quarter. One dark evening last week, however, the fiery imp was all activity in the locality of the peat moss, to the west of this, and created some excitement by his 'flitting, flaunting flame.' Decayed vegetable or animal matter, it is well known, is the cause of this light. In damp churchyards, in the olden time, where dead bodies were not buried far under the surface, such lights poured forth, and among our fore-fathers were familiarly known as 'dead lights.' In a dark age, and while such lights were so frequently cast forth, it is scarcely to be wondered at that superstitious beliefs were closely associated with such appearances."—*Fife News.*

*** This phenomenon, known variously as *ignis fatuus*, jack-o'-lantern, will-o'-the-wisp, corpse candles, etc. is a form of chemical luminescence produced by the combustion—usually spontaneous—of mixtures of gases released by rotting vegetation. The gases involved include methane, phosphine and hydrogen sulphide. Combustion takes place at low temperatures, little if at all above that of the ambient air; the 'flames' may flicker just above the ground or surface of a bog, or may float along in a light breeze.

Obituary

We record with regret the death on 22 April 1980 of Mr B. A. Halls, Assistant Scientific Officer, who was at the time on secondment to WMO in Geneva where he was employed in monitoring the operation of the World Weather Watch. Mr Halls joined the Office in 1964 as a specialist teleprinter operator in the Telecommunications Branch and transferred to the Scientific class in 1966. He was seconded to WMO in November 1976.

We record with regret the death on 26 May 1980 of Mr S. A. Darke, Assistant Scientific Officer, Cardiff/Wales Airport. Mr Darke joined the Office in October 1978.

Official publication

The following publication has recently been issued:

Solar radiation data for the United Kingdom 1951–75. Bracknell, Meteorological Office, 1980.

This 110-page publication summarizes solar radiation data from both Meteorological Office and co-operating stations for the period 1951–75, providing a useful reference for meteorological, building and agricultural research and for commercial solar-heating organizations.

After an introduction describing the radiation instruments used, the following four sets of tables are presented:

(a) Frequency distributions of hourly irradiations for 11 stations for each month for the period 1966–75.

(b) As (a) for daily irradiations.

(c) Monthly irradiation totals available from 26 stations for the 25-year period 1951–75.

(d) Numbers of consecutive days with irradiation above and below given thresholds for 6 stations.

Additionally, monthly maps of mean daily global irradiation (Cowley, J. P., 1978, *Meteorol Mag*, **107**, 357–373) are reproduced.

Publication received

The following publication has been received:

Syllogeus No. 26, *Climatic change in Canada*, edited by C. R. Harington. Ottawa, National Museums of Canada, 1980.

This issue consists of a project on climatic change in Canada during the past 20 000 years and contains five discussions by different experts in the field. It is hoped that they will animate research and policy-making groups in research institutions throughout Canada. A copy is held in the National Meteorological Library, Bracknell.

[illegible]

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NOTICES

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